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TITLE: GEOLOGY OF SERI ISKANDAR WITH EMPHASIS ON RESERVOIR ROCK POTENTIAL

PREPARED BY:

MUHAMMAD FAKHRUZ RAZI BIN MUTUSSIN

13685

SUPERVISOR:

DR SWAPAN KUMAR BHATTACHARYA

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Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

GENERAL GEOLOGY OF SERI ISKANDAR WITH EMPHASIS ON RESERVOIR ROCK POTENTIAL

by

Muhammad Fakhruz Razi Bin Mutussin
13685

A project dissertation submitted to the

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Approved by,

____

(Dr Swapan Kumar Bhattacharya)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Muhammad Fakhruz Razi Bin Mutussin

ABSTRACT

This dessertation discussed primarily on the necessary properties of a rock to become a good oil or gas reservoir. Secondary discussion of the interim report would be in term of the general geology of the studied area and porosity and permeability of the surrounding rock in constituents of the primary discussion for further explain the necessity of the required properties with the reservoir potential.

A good reservoir properties of a rock is mostly based on its porosity and the interconnectivity of the pores within the rock or in other words is the permeability of the rock. The porosity and permeability of the rock form in two stages which are primarily during the deposition of the rock and secondarily after the depositional of the rock which caused by whether diagenesis or tectonic events.

The focus of this dissertation is to study and determine the potential of the outcropped rock around the study area to become a good reservoir rock in the subsurface. Proving the presence and potential of a reservoir rock in a petroleum system could lead to new hydrocarbon exploration if other elements of petroleum system such as source rock, trap, cap rock and migration also present.

A studied was conducted to determine the general geology of Seri Iskandar with the emphasis on its surrounding rock potential to be a reservoir rock in doing so produce more detail geological map of Seri Iskandar. In addition to that, determine the potential and contribution of reservoir rock in Seri Iskandar in unproven Paleozoic petroleum system of Kinta Valley.

ACKNOWLEDGEMENT

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 Background of Study

This project involve studying the general geology of Seri Iskandar, Perak with emphasis on reservoir rock potential. The project were conducted using geological mapping techniques discover the structural geology of the area. Some measurements were taken from several outcrops to determine the fault trends in the study area to determine the rocks potential as a reservoir rock.

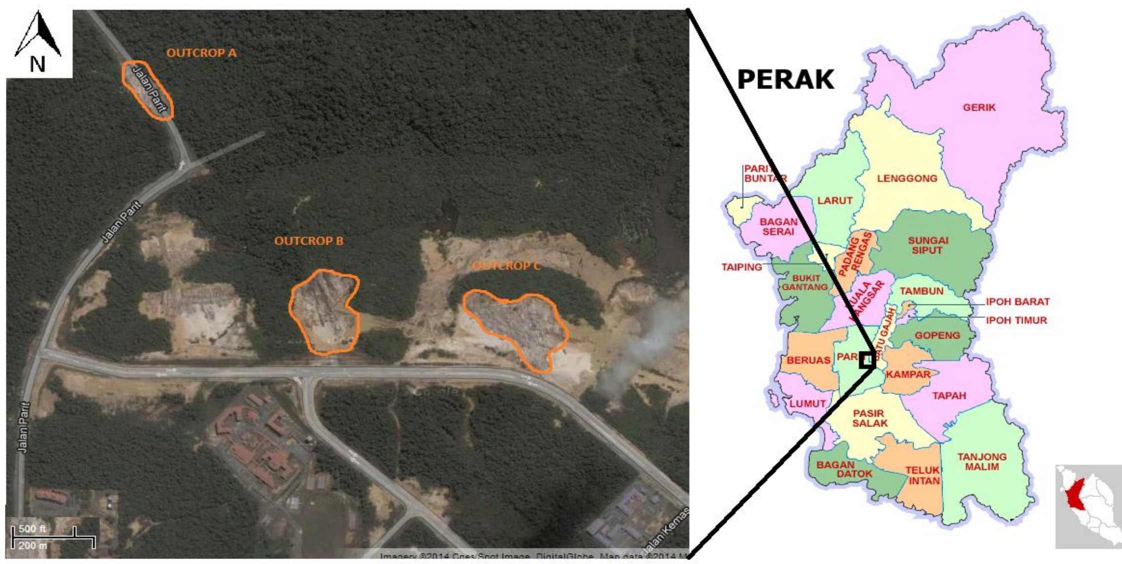

Figure 1: Map showing the location of the study area, Seri Iskandar in Perak Malaysia

Several outcrops are found in the Seri Iskandar area as shown in the Figure 1. These outcrops in particular are thick sequences of sandstone with minor interbeded beds of siltstone and shale.

The study area is easily accessible all outcrops are located beside the local main road. Most of the project area are covered with vegetation excluding the developed area and the outcrops. The projects were conducted in three different outcrops as shown in Figure 1 which are Outcrop A, Outcrop B and Outcrop C.

The purpose of this project other that as a final year project for petroleum geoscience undergraduate students is to understand the geological background of the study area and to study the potential of the outcropped rock within the study area to be a subsurface reservoir.

Few specialization techniques will be used in this project such as mineralogy and petrophysical study. Mineralogy specialization technique will be used in interpreting the minerals in thin sections and petrophysical study specialization technique will be used in determining the necessary properties of rock to be a good reservoir such as porosity and permeability.

Based on the test results and the geological mapping, conclusions about the potential of the outcropped sandstone in Seri Iskandar area to be a subsurface reservoir and its extent in the subsurface is made.

1.2 Problem Statement

Detailed geological map of Seri Iskandar area is not available, as a result it caused geologist to interpret the geology of this area inaccurately. Hence, studies were conducted to acquire information and accurately produce a map that will outline the main geological outcrops in Seri Iskandar area. Does the sandstone in Seri Iskandar area are good enough to be a reservoir rock? Porosity and permeability test will be handled to evaluate the rock properties.

1.3 Objectives

The objectives of this project are:

- To study the general geology of Seri Iskandar area with emphasis on the reservoir rock potential
- Producing a detailed geological map of Seri Iskandar
- To conduct porosity and permeability test to several samples from outcrops to determine the potential of the rock to be a reservoir rock

1.4 Scope of Study

The scopes of study for this project can be simplified as follows:

- Study past research papers, journals or books to collect information about the geological history of Seri Iskandar and to learn what kind of research have been done in the area
- Understand the general geology of Seri Iskandar
- Study the potential of the rock in Seri Iskandar to be a reservoir rock

CHAPTER 2: LITERATURE REVIEW

2.1 Geology of Peninsular Malaysia

There are for main geological domains of Peninsular Malaysia which are Northwest, West, Central and East domain. The boundaries of these domains are based on Bentong – Raub suture zone that extended from north to south. The differences between these four domains are based on their respective structural trend, style, mineralization types, lithology, facies and paleogeography. There are two sedimentation regimes at Peninsular Malaysia which are western regime (Cambrian Permian Succession) and eastern regime (Carbo Permian strata) (Foo, 1990).

The western belt consists of the Main Range, Bintang Range and Kledang Range. The age of these granitic rocks range from Permian to Cretaceous. Majority of the granitic rocks are Triassic age where during the intrusion causes folding and deforming many of the older strata occur (Bignell & Snelling, 1977).

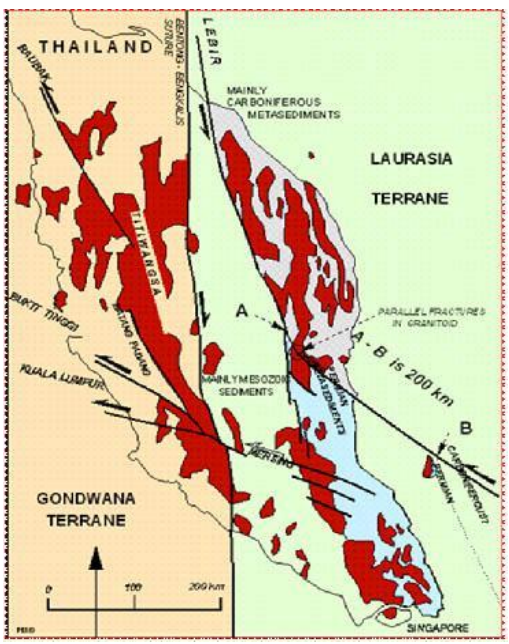

Figure 2: Granitoids of Peninsular Malaysia, Modiffied after Hutchison & Tan (2009) showing distribution of granitic bodies in relation to Bentong Raub suture zone

2.2 General Geology of Seri Iskandar

According to Fontaine and Amnan (1995), the crop out sandstone in Seri Iskandar is believed as the extension of the Kinta Valley narrow and elongated alluvial plain that consists of mainly carbonates which are widespread and vary in thickness with rare clastic sequences. The crop out clastic sequence are thick sequences of sandstone with minor interbeded beds of siltstone and shale which are equivalent to the characteristics of Kati Beds which are located around and south of Kuala Kangsar.

Kati Beds was introduced by Foo (1990). The renamed Kati Formation is interpreted as equivalent to the Kubang Pasu Formation (Hutchison, 2007). This formation are poorly exposed and sparsely distributed and also heavily weathered. The position of Kati Beds confirmed by boreholes located in dense tropical rain forest. The Kati Beds are highly folded and located between the granites of the Bintang and Kledang Ranges (Foo, 1990). Lee, C. P. (2009) stated that there are no fossils have been found within the Kati beds, hence a probable Upper Palaeozoic (Carboniferous to Permian age) was assigned based on the highly flexure of the beds compared to the Triassic Semanggol Formation rocks above them and based on limestone dated Ordovician to Devonian underlain the bedrock. Foo (1990) also stated that Kati Beds is older that Semanggol Formation based on dissimilarities of the lithology and folding style between those two formation. Although, Ingham and Bradford (1960) stated that Kati Beds is younger than Semanggol Formation. The actual thickness of this formation is hard to identify, but according to Wong (1991) it is estimated to be about 900m thick.

Kati beds are weakly metamorphosed because has not been affected directly by regional metamorphism. Part of Kati beds that close to granite intrusion were metamorphosed into hornfelses. The contact between Kati beds and the granite intrusion was observed along Sungai Dal. Kampung Buaya (Foo, 1990).

The depositional environment for Kati Beds interpreted as deep water environment by Foo (1990) due to the inexistence of wave motion structure. However this interpretation is not convincing because some issues have not been discussed and lack of evidence. According to Wong (1991), Kati Beds most probably deposited in moderately deep water. The absence of traction current structure and cross bedding does not support any fluvial or deltaic origin. The occurrence of flute cast and graded beds in Bukit Tunggal suggest the involvement of turbidity currents. However, the interpretation of environment of deposition of Kati Beds by Wong are not supported by biostratigraphic analysis but still provides a useful information regarding the depositional setting.

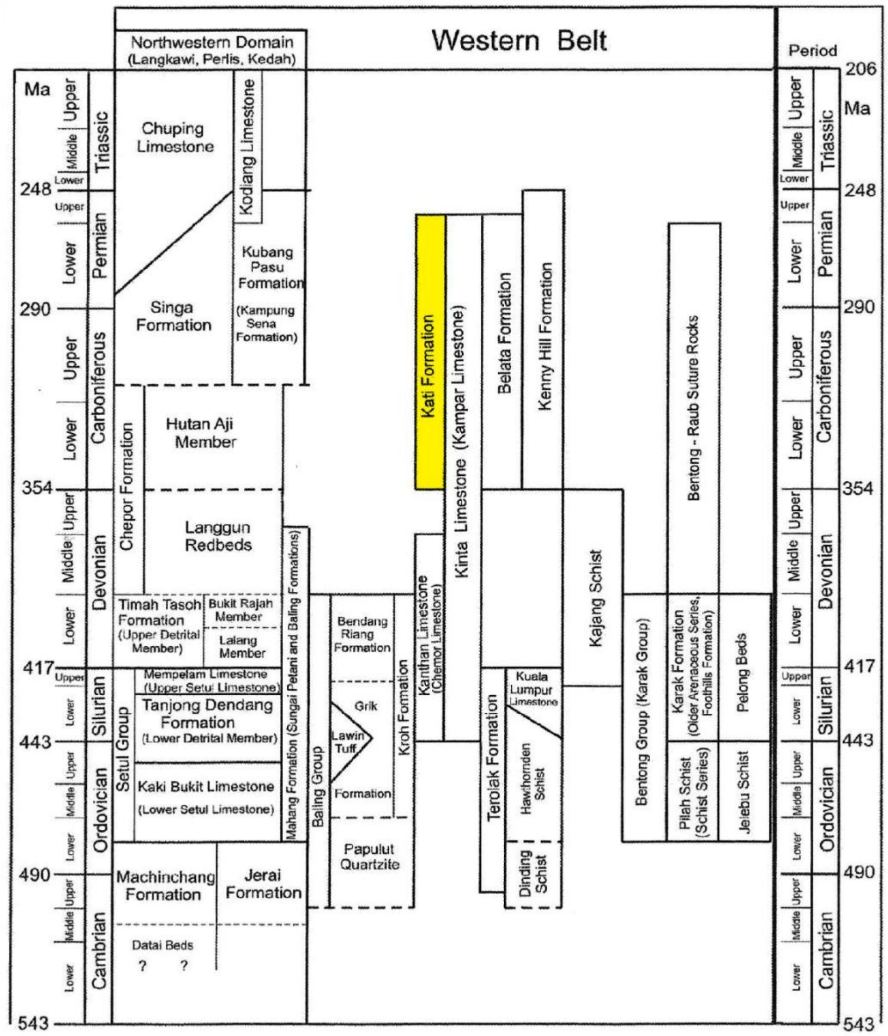

Figure 3: Stratigraphic chart of Paleozoic sequences of the western belt of Peninsular Malaysia by Lee (2009)

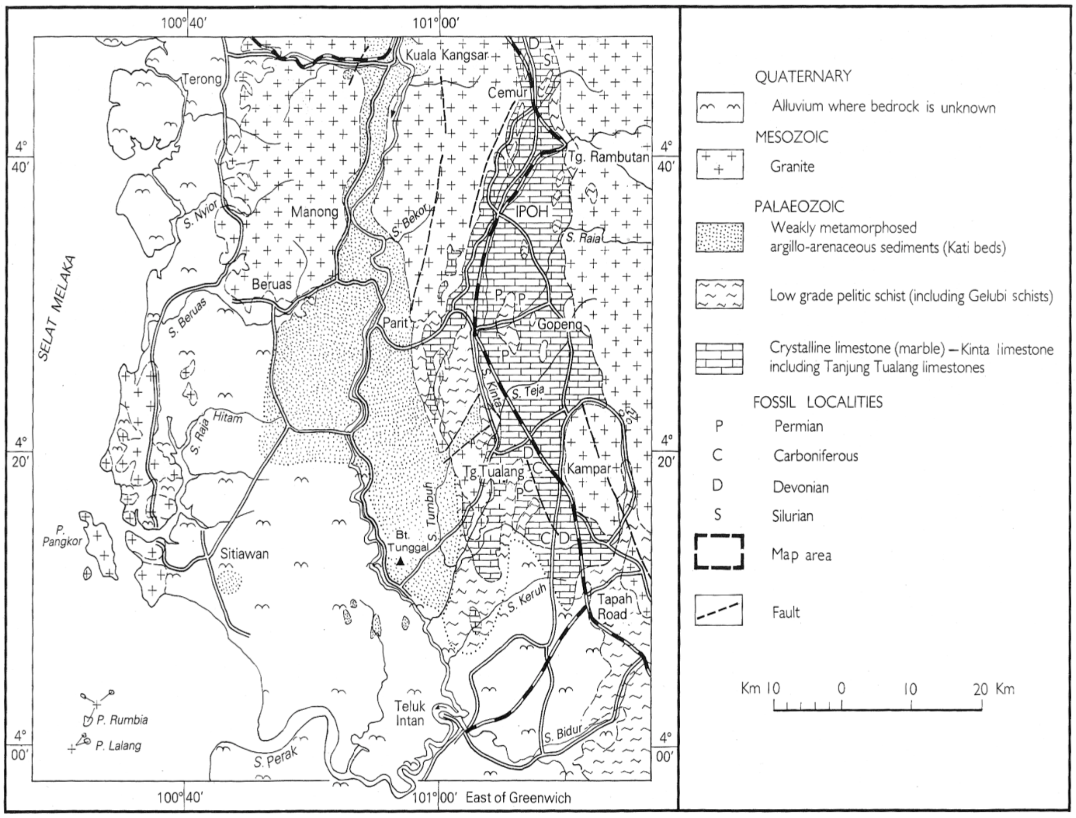

Figure 4: Distribution of Kati Beds throughout Perak

2.3 Reservoir Rock

Reservoirs are the porous and permeable rocks that can host any kind of fluid deposits such as gas, oil or water. So, in order to have a good reservoir rock, the rock should have both good porosity and permeability.

Major type of rock found in Seri Iskandar area are sandstone. Since the majority of petroleum reserves in the world found in ancient sandstones which have porosity and permeability. It is referred to as sandstone reservoir which the Seri Iskandar area might have the potential for it. Sandstone reservoirs are normally composed of stable minerals such as quartz, feldspar and rock fragments. It also composed of accessory minerals and pores saturated with fluids. To be included as sandstone, the grain of the rock should be between 1/8 and 2 mm in diameter. The quantity of pore volume and the connectivity between the pores may related to the primary processes under which the sandstone accumulated, or it may related to secondary changes that are post-depositional. In Seri

Iskandar case, since there were a lot of tectonic events that have been occurred, secondary changes might give big effect in porosity and permeability of the rock with related to fracture.

According to Amyx et al., (1960) porosity can be define as the ration of the volume of void space (the spaces between the grains) or open space in the rock to the bulk volume (the overall volume of the voids plus the grains) of that rock, usually defined in term of percentage.

$$\emptyset = \frac{V_p}{V_b} = \frac{V_p}{V_p + V_g}$$

The equation to calculate porosity is as stated above where Ø is porosity, V_p is void space or pore volume, V_b is bulk volume, and V_g is grain volume.

There are two type of porosity in rock which are primary and secondary. Primary porosity is the original void space in a rock which formed during the deposition of the rock. For secondary porosity, it is a separate porosity system that is formed after the sediment is deposited. It occurs commonly by processes such as dolomitization, dissolution, fracturing and diagenesis. Factors controlling porosity are grain shape, grain size distribution (sorting), compaction, cementation, clay, dissolution of grains and fracturing.

Permeability is the property of rock as indication of the ability of fluid to flow through rocks. The unit measurement for permeability is darcy (D). High permeability means that fluid can flow easily through the rock. The permeability of rock is dependent on the continuity of the rock pore spaces or can be called as effective porosity.

CHAPTER 3: METHODOLOGY

The project starts with reconnaissance survey to locate available outcrops within the study area and determine the location of those outcrops in the topographic map. The next step for the project is fieldwork and sample collection. The aim is to collect a minimum of one sample from each outcrops within the study area. Firstly, all the collected samples will be cored and analyzed using Steady State Permeameter and Porosimeter (Poro-Perm) to measure the required properties of the rock to be a reservoir such as porosity and permeability. Next, for petrography study, thin section for each samples will made and analyzed under the Electro-Magnetic Microscope. Finally, from the collected data in the laboratory analysis, the potential of the rock in the studied area to be subsurface reservoir will be determined.

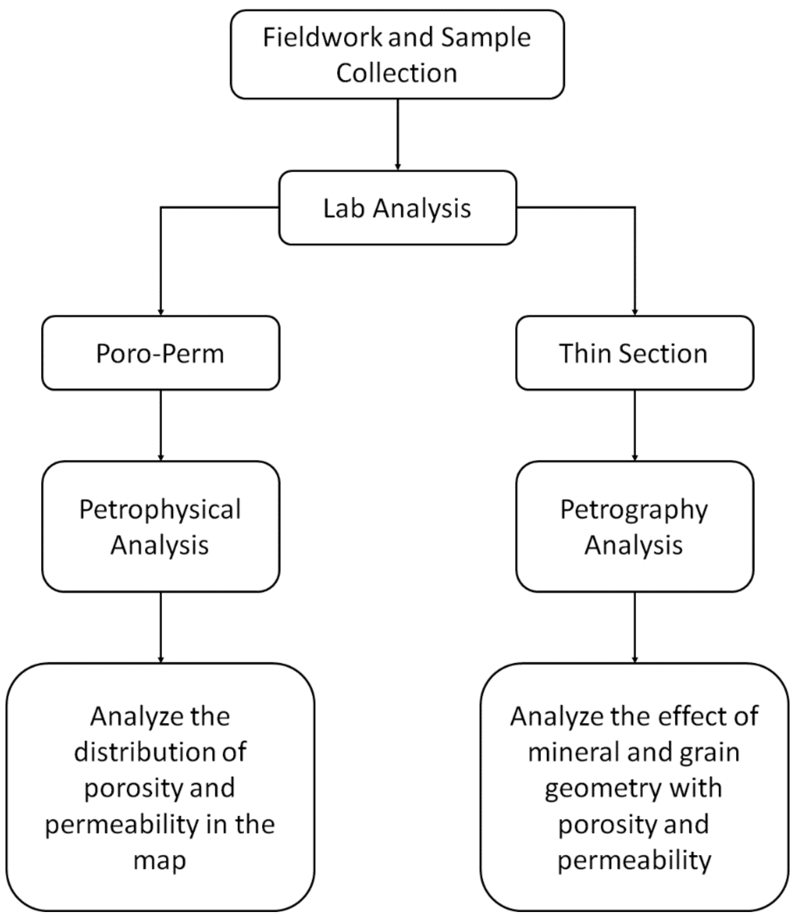

Figure 5: Method of Analysis

3.1 Project Flow Chart

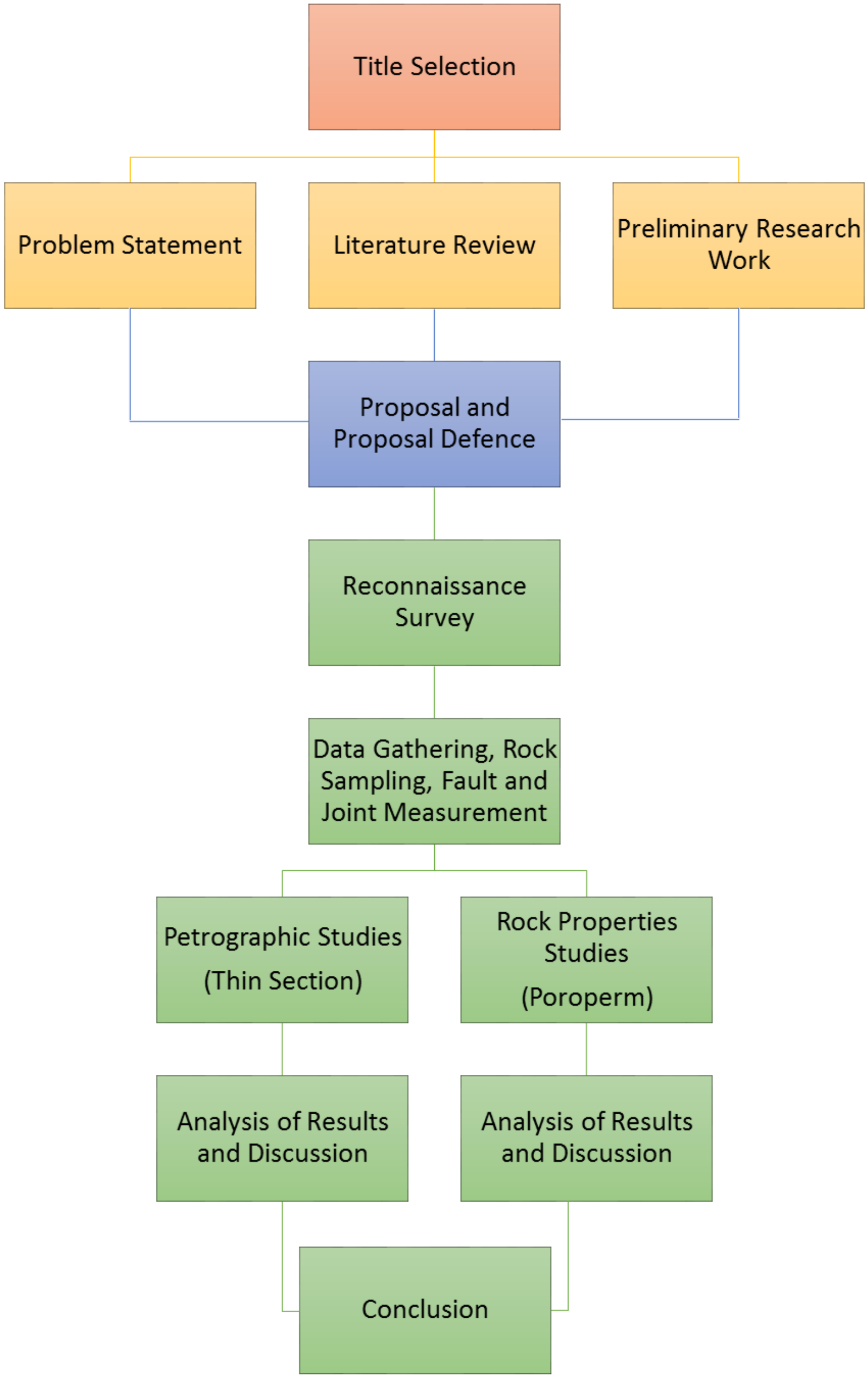

Figure 6: Workflow for the whole project

3.2 Gantt Chart and Key Milestone

Table 1: Gantt Chart for FYP I

No	Detail Work	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic	■	■												
2	Preliminary Research Work			■	■	■									
3	Submission of Extended Proposal						●								
4	Proposal Defence								■	■					
5	Project Work Continues										■	■	■		
6	Submission of Interim Draft Report													●	
7	Submission of Interim Report														●

LEGEND:

Process ■

Suggested Milestone ●

Table above is the Gantt chart for the first semester of this project with suggested key milestone to make sure the project is progressing well. It start with topic selection and proceed with proposal defense to check the benefit and relevancy of the project for the student. If the proposal is approved, then proceed with the field-work and lab analysis. There will be submission of several reports throughout the project to check the progress of the project.

Table 2: Gantt Chart for FYP II

No.	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Work Continues	■	■	■	■	■	■	■								
2	Submission of Progress Report							●								
2	Project Work Continues								■	■	■	■	■			
4	Pre-SEDEX										●					
4	Submission of Draft Final Report											●				
6	Submission of Dissertation (Soft Bound)												●			
7	Submission of Technical Paper												●			
8	Viva													●		
9	Submission of Project Dissertation (Hard Bound)															●

Progress ■
Suggested Key Milestone ●

Table above is the Gantt chart for second semester of the project. Half of the semester will focus on finishing all required test or analysis for the project to acquire necessary data for interpretation and conclusion for the project. Then, the last part of the project is finishing the final report.

3.3 Reconnaissance Survey

This project are using several technique with its own procedure. There are three major procedure that will be done which are geological mapping technique to create the geological map of Seri Iskandar. For rock properties study, thin section study and porosity-permeability test will be done to evaluate the rock potentials as reservoir. The first step before proceed into all those tests mentioned above, the project start with reconnaissance survey.

Reconnaissance Survey was done as another alternatives to locate suitable outcrops for the project. This survey is done by roughly identified the lithology of surrounding rocks and to plan which road or path should be followed to study the area.

3.4 Field-Work and Sample Collection

After the reconnaissance survey was done and all available outcrops have been located, the project proceed with the field-work and sample collection. In this part, all the samples and the geological descriptions (more detail compare to reconnaissance survey) of the area is collected together with the coordinate location for mapping purposes. The basic geological description would be the bedding dipping angle and the strike direction together with the rock description of the area.

3.4.1 Equipment and Instruments

There are two main group of equipment and instruments used throughout this project.

Table 3: List of Equipment and Instruments Used

Field-Work and Sample Collection	Rock Lab Analysis
• Geology Hammer • Compass • Global Positioning System (GPS) • Measuring Tape	• Rock Cutter Machine • Coring Machine • Rock Trimmer • Micro-Cutter • Poro-Perm Machine • Caliper • Heater • Resin with Blue Dye • UV Light • Weight Balance • Epoxy Glue • Polishing Powder

3.4.2 Geological Mapping Technique

- The first step is obtaining the base map of the study area such as topographic map.
- Second step is create the geological map by:
    - Visiting the study area
    - Determine the lithology of the rock in the study area and record any different type of rock contact and record the coordinate of each outcrop visited
    - Take measurement for fault and joints as much as possible for fracture analysis
    - Compare the recorded coordinate of outcrop with the base map to locate the outcrop in the base map

3.4.3 Core Plug Preparation

All samples that were collected in the field need to be prepared for the lab analysis. For rock properties study which is Poro-Perm, the samples need to be in core shape with diameter of 1” or 1.5” to fit in to the Poro-Perm machine. The samples were prepared by using rock cutter, core machine and rock trimmer.

3.4.3.2 Core Plug Preparation Procedure

1. Cut the rock using the rock cutter to desire such which fit the core machine.
2. Put the rock inside the core machine and hold it by tightening the rock holder.
3. Switch on the machine; make sure the fluid (cooling agent) is flowing. Continue coring the sample. Caution: Coring machine is a dangerous machine to be operated. Please use all necessary safety equipment.
4. After the core bit has penetrated through the sample, stop the machine and collect the sample.
5. Trip the sample to desired length using the rock trimmer machine.

Figure 7: 1 - Core Machine, 2 - Rock Trimmer, 3 - Rock Cutter

3.4.4 Thin Section Preparation Procedure

1. Preparing the sample
   - Most resins that are used for fixing the soil samples are hydrophobes, any water must be extracted first. Hence, drying the samples are essentials
   - Some of the rocks are easily crumble and cannot be polished. Hence, after drying the samples, resins with blue dye used to harden it as also to add the ability to see pore space in the thin section. The rock have to be permeable to allow resins filling in the pore space.
2. Prepare the glass slide
   - The glass slide need to be flat on both sides
   - One side of the glass need to be polished to create a suitable contact surface with the rock sample
3. Cut the rock slab
   - Turn the rock into slab size
4. Clean up the slab
5. Cut the chip
   - The slab size need to be reduced into rock chip
6. Glue the slide to the chip
   - Glue the slide to the chip using epoxy
7. Cut the chip from the slide
8. Grind slide to the correct thickness

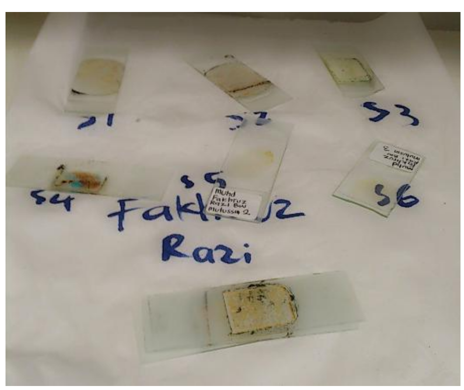

Figure 8: Completed Thin Section Slides

3.4.5 Steady State Gas Permeameter and Porosimeter (Poroperm)

1. Measure the diameter and length of the core plug using a caliper for accurate measurement.
2. Weigh the core plug using the weight balance.
3. Put the core plug inside the coreholder.
4. Set the confining pressure to 380 psi (Should not be exceeding 400 psi).
5. Select the matrix cup in accordance to sample series (1”, 1½”)
6. Fill the sample measured information in the active file. (The important information is the core’s length, diameter and weight)
7. Click on the Measurement button to start the test.
8. The results is available in active file.

Figure 9: 1 - Poro-Perm Machine, 2 - Core Samples, 3 - Caliper, 4 - Weight Balance

CHAPTER 4: RESULTS AND DISCUSSION

4.1 General Geology of Seri Iskandar

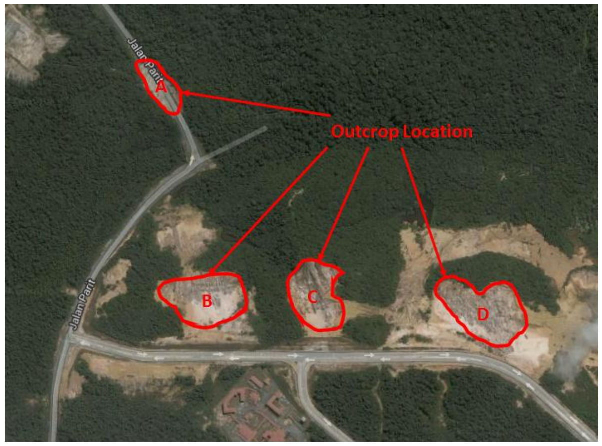

Figure 10: Location of Outcrops. From left (Outcrop A, B, C and D).

4.1.1 Rock Type

Main general classification of rock that can be found in Seri Iskandar area is sedimentary rock. Sedimentary rock such as sandstones, shale, mudstone and shale can be observed in the study area but sandstone has the biggest ratio compared to other type of rocks in Seri Iskandar area. For mudstone, the color is darker compared to siltstone but this cannot be used to justify the rock type due to heavy weathering. Both mudstone and siltstone are easily crumbled but different for sandstone and shale which are harder even though in some area, the sandstone is friable and cannot be cored.

For grain size analysis, the mudstone grain size is less than 0.004 mm and the grain are intact to each other resulting in clay like texture. The grain size for siltstone is coarser that mudstone which is around 0.004 mm to 0.06 mm and when crumbled, it form a powdery texture. Shale usually consists of both clay and silt mineral. Sandstone in the area have grain size ranging from medium to fine sand (0.5 mm – 0.25 mm).

4.1.2 Bedding Orientation

The dipping angles for the beddings are ranging from as low as 39° to as high as 87°. Therefore, the general trend of the bedding is a steep dipping bedding which is near to vertical beddings. In outcrop A as shown in map in Figure 10 is an outcropped big blocky sandstone with no bedding plane or strike direction and full of fractures.

4.1.3 Fracture Orientation

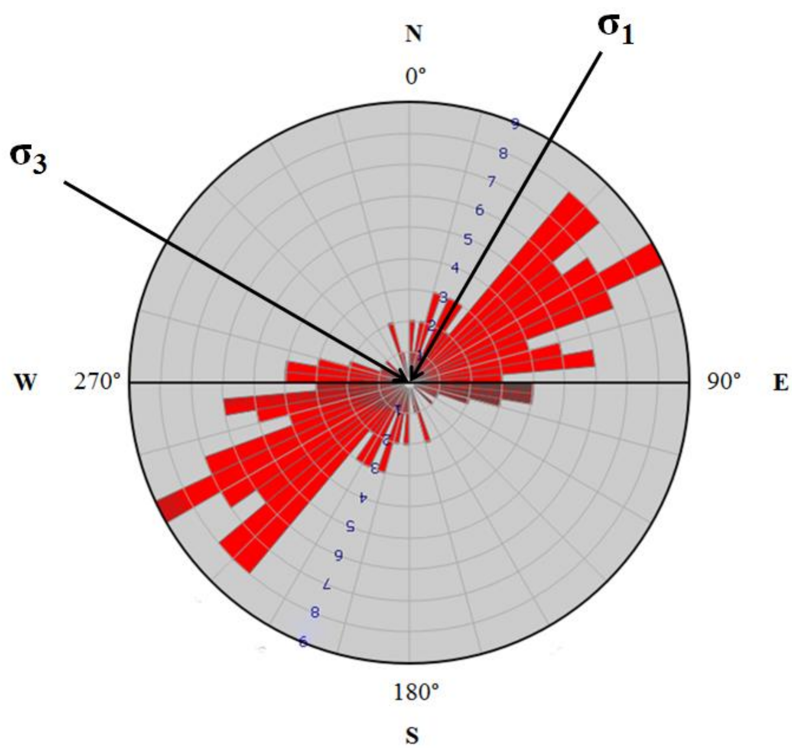

Figure 11: Rose Diagram for the fracture orientation of Outcrop A

Rose diagram shown above is based on strike and dip of fracture data collected from Outcrop A. The rose diagram showing that the fracture trend is NE – SW. Based on the rose diagram, it can be interpreted that σ_1 which is the major stress and σ_3 which is the minor stress perpendicular to the σ_1. The direction of σ_1 is correlatable with the regional stress which is coming from the granitic intrusion NW of studied area.

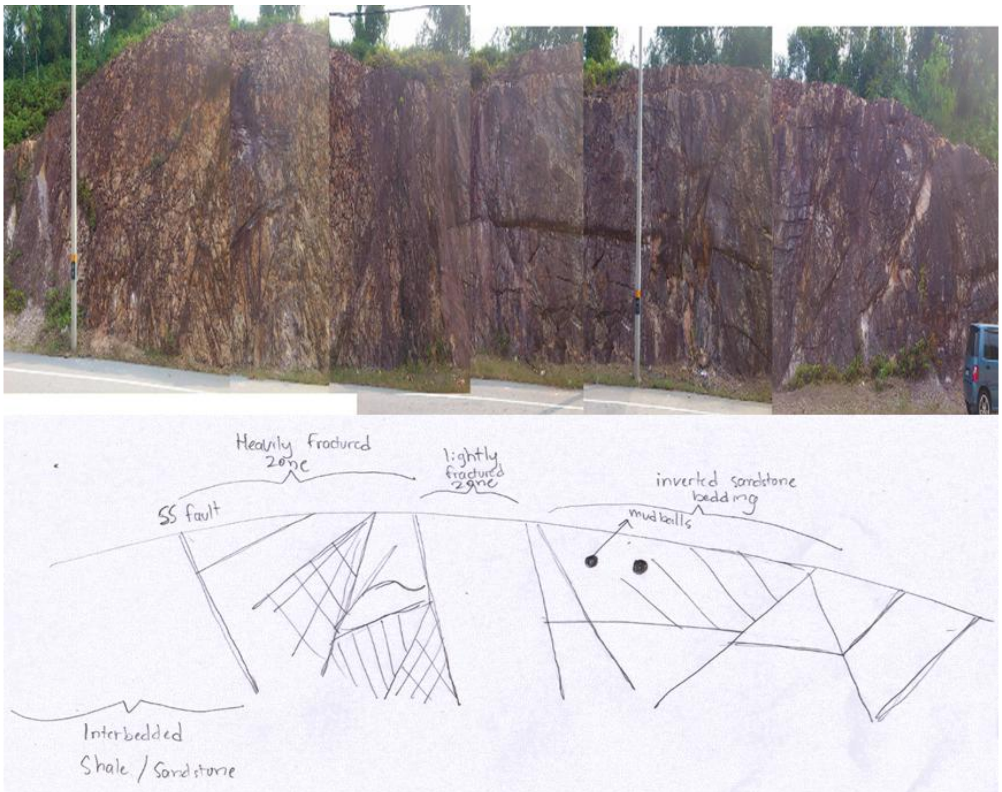

Figure 12: Fractures orientation of Outcrop A. Various angle of joints and faults. (Scaled over a car (right side of picture)).

4.1.4 Geological Map of Seri Iskandar area

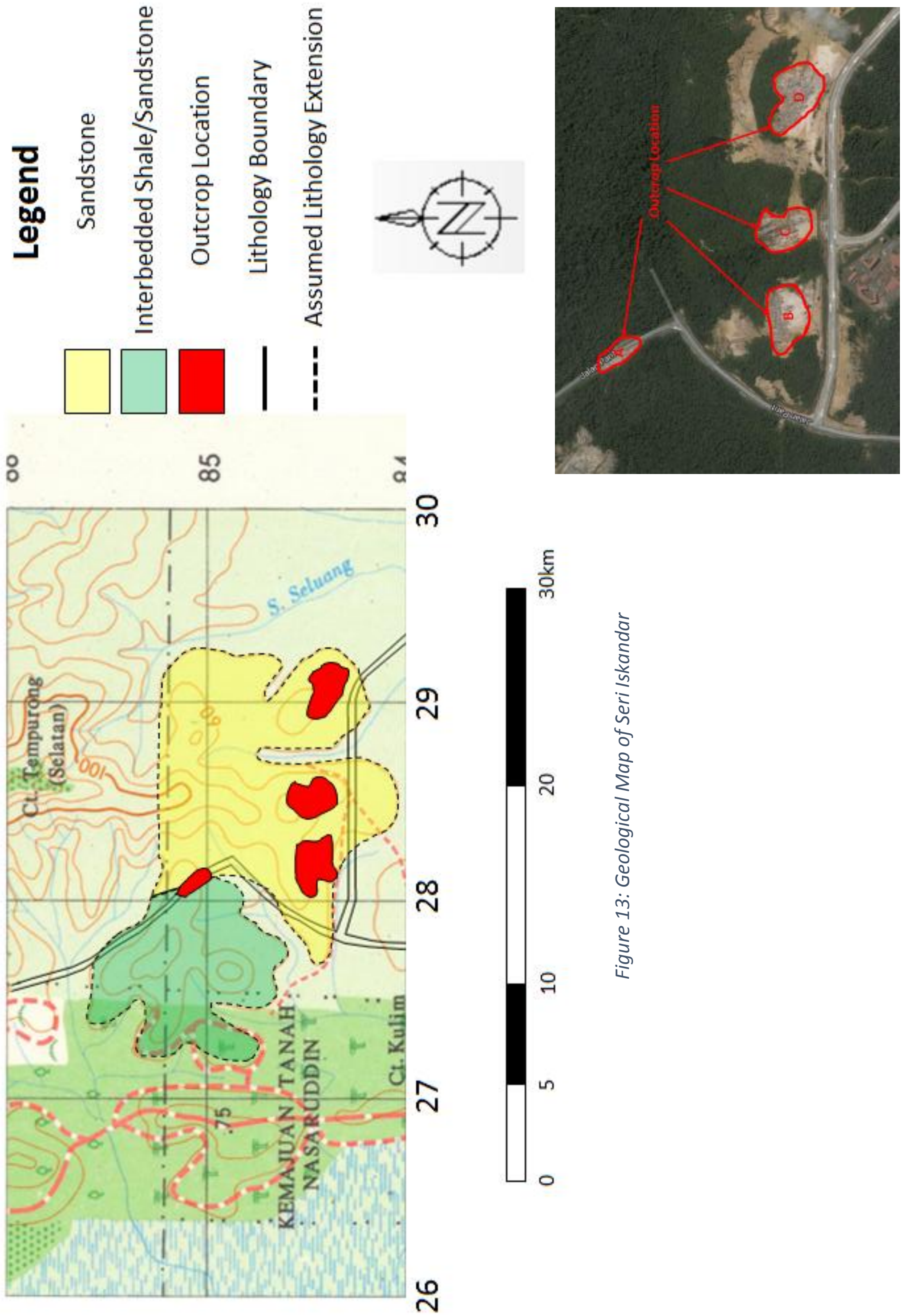

Figure 13: Geological Map of Seri Iskandar

4.1.5 Cross-Section of Seri Iskandar area

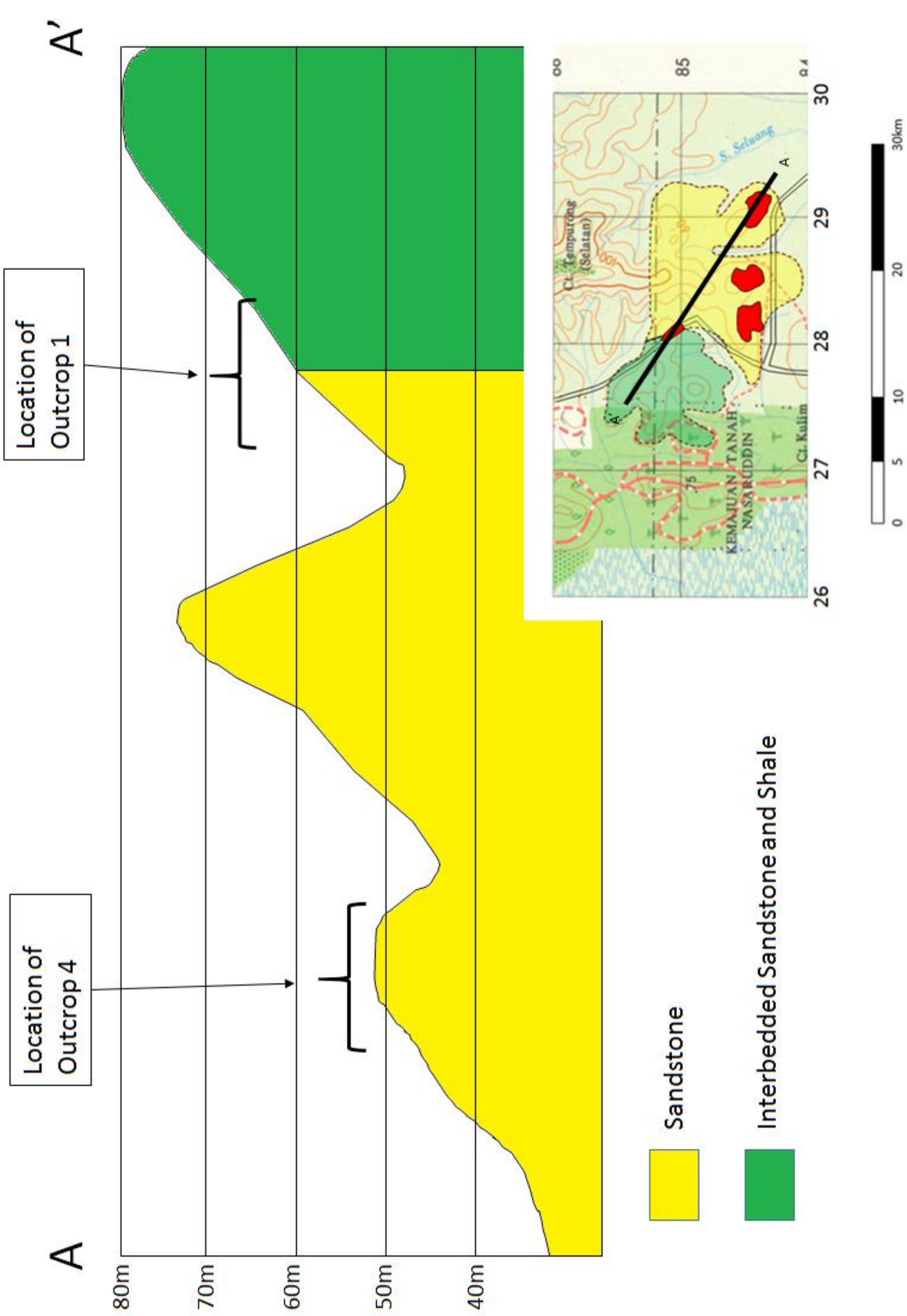

Figure 14: Cross Section Crossing Study Area

4.2 Reservoir Studies Results

4.2.1 Rock Properties Study

Tables shown below is the results of Poro-Perm test for S1, S2, S3, S4, S5 and S6

4.2.1.1 S1

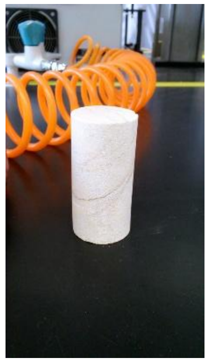

Figure 15: S1

Table 4: Test Results

Description	Value
Temperature (°C)	27
Humidity (%)	67
Sample Length, L (mm)	78.51
Sample Diameter, D_o (mm)	38.22
Sample Weight (g)	217.62
Pressure Confining (Psig)	388
Sample Porosity, ϕ (%)	0.129
Sample Permeability (mD)	0.109
Sample Pore Volume, Vp (cc)	0.116
Sample Bulk Volume, Vb (cc)	90.073
Sample Grain Volume, Vg (cc)	89.957
Sample Grain Density (assuming the sample is weighed), ρg (g/cc)	2.419

4.2.1.2 S2

Figure 16: S2

Table 5: Test Results

Description	Value
Temperature (°C)	27
Humidity (%)	65
Sample Length, L (mm)	77.35
Sample Diameter, D_o (mm)	38.22
Sample Weight (g)	210.57
Pressure Confining (Psig)	393
Sample Porosity, ϕ (%)	1.867
Sample Permeability (mD)	0.023
Sample Pore Volume, Vp (cc)	1.657
Sample Bulk Volume, Vb (cc)	88.754
Sample Grain Volume, Vg (cc)	87.097
Sample Grain Density (assuming the sample is weighed), ρg (g/cc)	2.418

4.2.1.3 S3

Figure 17: S3

Table 6: Test Results

Description	Value
Temperature (°C)	27
Humidity (%)	66
Sample Length, L (mm)	64.23
Sample Diameter, D_o (mm)	38.09
Sample Weight (g)	162.55
Pressure Confining (Psig)	407
Sample Porosity, ϕ (%)	31.492
Sample Permeability (mD)	0.12
Sample Pore Volume, Vp (cc)	23.049
Sample Bulk Volume, Vb (cc)	73.19
Sample Grain Volume, Vg (cc)	50.141
Sample Grain Density (assuming the sample is weighed), ρg (g/cc)	3.242

4.2.1.4 S4

Figure 18: S4

Table 7: Test Results

Description	Value
Temperature (°C)	27
Humidity (%)	67
Sample Length, L (mm)	79.39
Sample Diameter, D_o (mm)	37.73
Sample Weight (g)	221.53
Pressure Confining (Psig)	380
Sample Porosity, ϕ (%)	9.082
Sample Permeability (mD)	1.826
Sample Pore Volume, Vp (cc)	8.062
Sample Bulk Volume, Vb (cc)	88.762
Sample Grain Volume, Vg (cc)	80.701
Sample Grain Density (assuming the sample is weighed), ρg (g/cc)	2.745

4.2.1.5 S5

Figure 19: S5

Table 8: Test Results

Description	Value
Temperature (°C)	27
Humidity (%)	67
Sample Length, L (mm)	64.32
Sample Diameter, D_o (mm)	37.98
Sample Weight (g)	176.81
Pressure Confining (Psig)	381
Sample Porosity, ϕ (%)	9.298
Sample Permeability (mD)	0.204
Sample Pore Volume, Vp (cc)	6.776
Sample Bulk Volume, Vb (cc)	72.87
Sample Grain Volume, Vg (cc)	66.094
Sample Grain Density (assuming the sample is weighed), ρg (g/cc)	2.675

4.2.1.6 S6

Figure 20: S6

Table 9: Test Results

Description	Value
Temperature (°C)	27
Humidity (%)	68
Sample Length, L (mm)	79.43
Sample Diameter, D_o (mm)	37.84
Sample Weight (g)	188.53
Pressure Confining (Psig)	380
Sample Porosity, ϕ (%)	16.946
Sample Permeability (mD)	0.109
Sample Pore Volume, Vp (cc)	15.137
Sample Bulk Volume, Vb (cc)	89.326
Sample Grain Volume, Vg (cc)	74.189
Sample Grain Density (assuming the sample is weighed), ρg (g/cc)	2.541

4.3 Results Analysis

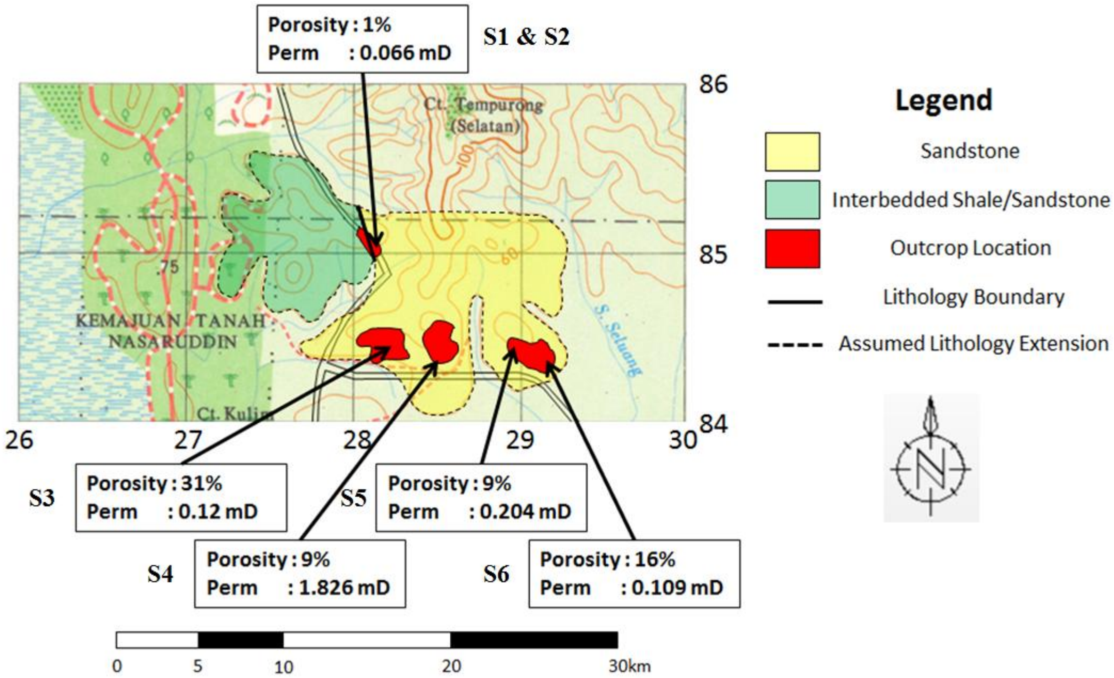

Figure 21: Summary of Poro-Perm Test with location of samples taken.

Map above is the summary of Poro-Perm test according to the location of the samples taken. Referring to the results acquired, it can be observed that the distribution of porosity throughout the area is not consistent and does not have specific range of porosity. Some of the samples are tight sandstone with only 1% porosity and some sample have good porosity and the highest is 31% and the difference is very high.

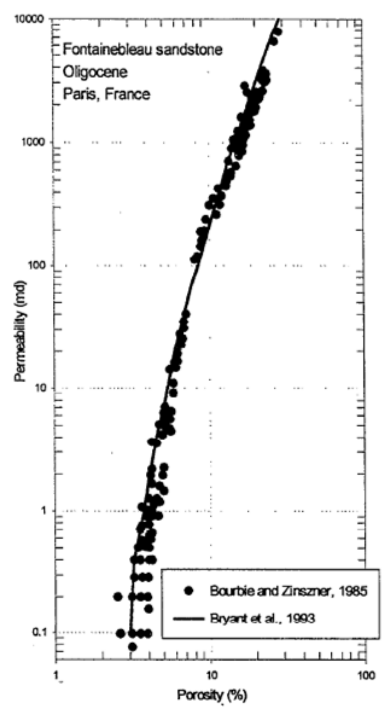

Figure 22: Permeability vs Porosity Graph, Bourbie and Zinszner (1985).

There is no relationship between porosity and permeability that can be observed based on the results. Some theory stated that permeability is dependent on porosity. Based on data from Fountainebleau sandstone, Bourbie and Zinszner (1985) come up with the graph (Figure 22) that show permeability increasing linearly with porosity.

According to Nelson P. H. (1994), porosity can be a good predictor for permeability because porosity reduction is always accompanied by a reduction in characteristic pore size because as compaction and diagenesis affecting a rock, the pore space of the rock will be reduced and permeable pathways are gradually obstructed in a systematic way that maintain consistent relationship between porosity and permeability but only applicable to certain type of sandstone.

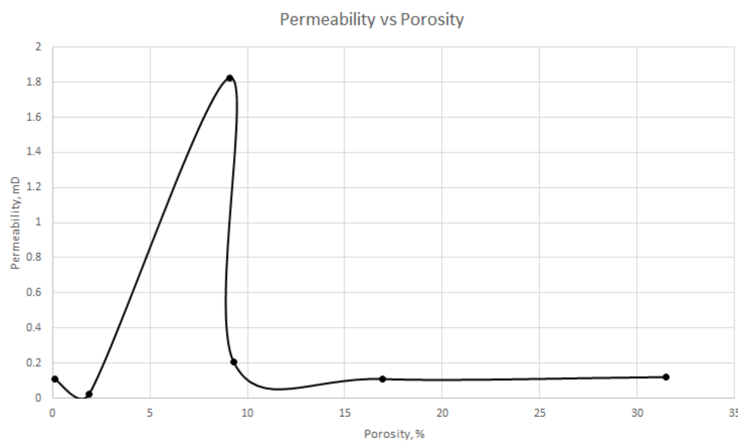

Figure 23: Permeability vs Porosity graph for Seri Iskandar area

Although, in Seri Iskandar sandstone case, those idea is inapplicable. Graph above is based on data acquired at Seri Iskandar area and it obviously different compared to the graph by Bourbie and Zinszner (1985) because the permeability for every sample is constantly low. The permeability of the rock obviously cannot be predicted using porosity value as stated by Nelson. The highest permeability value is 1.826 mD which still can be considered as low permeability.

Inconsistent porosity distribution and constant low permeability is might be due to the weathering effect. Speculation can be made that the porosity and permeability for the Kati Beds sandstone around Seri Iskandar area have a good porosity and permeability in the first place but then ruined by the heavy weathering process. Weathering process may had brought down clay particles by the flowing water down and filling up blocking the pore space of rock at lower location.

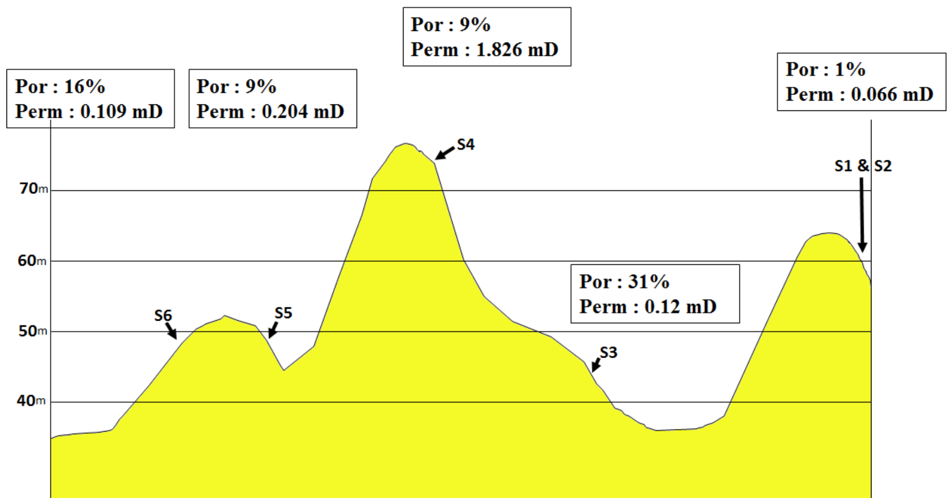

Figure 24: Sample location according to elevation and test results

Based on Figure 24, the weathering assumption can only be applied for permeability because the value of permeability for sample taken from higher ground which is S4 sample has higher permeability value compared to samples from lower ground. This cannot be applied to sample S1 and S2 maybe it is because the location of outcrop is further away from other outcrops. The weathering process might have cause the smaller particles to block the pore connectivity and reduce the permeability of the rock.

For porosity, it cannot be applied because comparing the porosity of S4 (9%) which is located at highest ground is lower compared to the porosity of S3 (31%) which is located at lowest ground.

4.4 Petrographic Studies

One of the factors that affecting or controlling porosity and permeability in a rock is the grain size distribution which is the sorting of the grain but porosity is independent of the grain size.

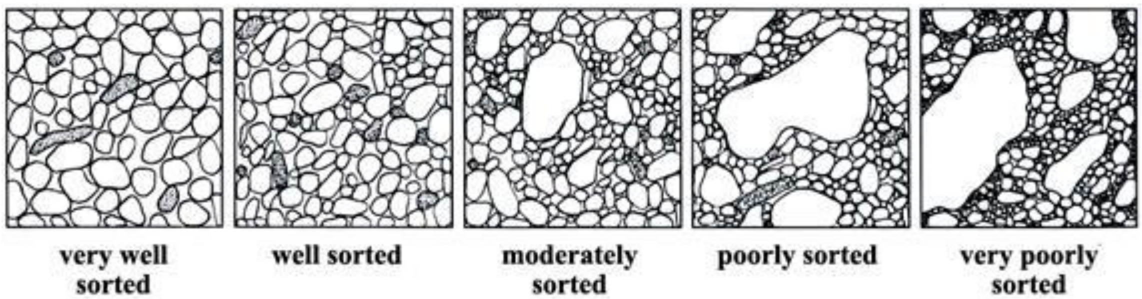

Figure 25: Grain Sorting Chart based on grain size composition, David (2011)

According to David (2011), grain sorting can be divided into five classification as shown in Figure 25. The grain sorting have a big impact on rock porosity and also permeability. In well sorted condition, the range of grain size is smaller compared to the poorly sorted condition.

Figure 26 shows how the range of grain size affecting pore volume in a rock. The smaller grain size filling up the void space between larger grain which can destroy the porosity of a rock.

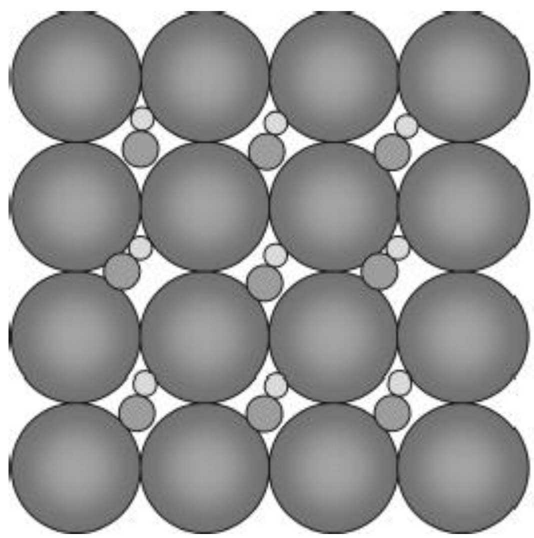

Figure 26: Effect or range of grain size to pore volume

Weather clay brought by rain or flowing water that fill in sandstone pores is acting the way like shown in Figure 26.

According to Nelson (2000), in very-well-sorted and extremely-well-sorted sand packs, permeability increases without any change in porosity.

Figure 27 is the thin section for every samples except for S6 sample because its friability make it difficult to polish the rock.

Based on grain sorting theory explained above, looking at the thin section of the samples, almost every sample can be categorized as poorly sorted except for S4 which can be categorized as moderately sorted.

The poor grain sorting might be the main reason for the low permeability of the rock in Seri Iskandar area. By comparing the sorting of S4 sample compared to other samples, it is sorted better and resulting in better permeability compared to other samples.

The porosity of the rock cannot be observed in the thin section because the rock is not permeable enough to let through the resin with blue dye and filling in the void space in time before it harden.

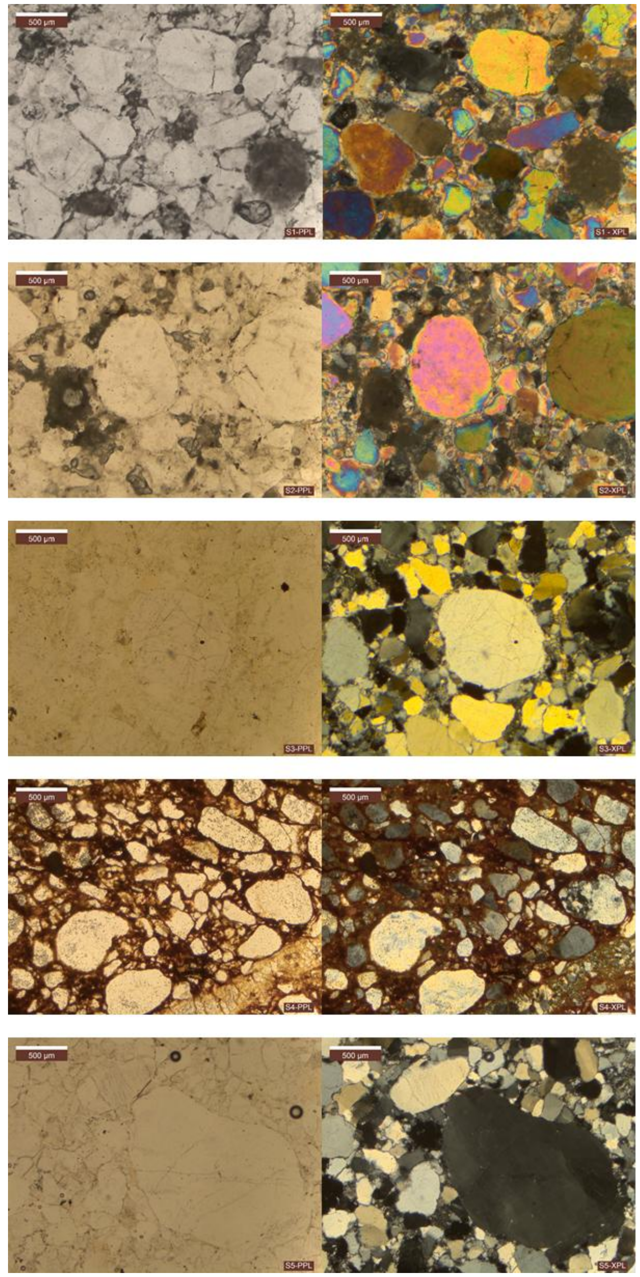

Figure 27: Thin Section for S1, S2, S3, S4, and S5. PPL (left) XPL (right)

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Factor that affecting the porosity and permeability of sandstone in Seri Iskandar area in is heavy weathering and based on the Poro-Perm results, it is proven that the sandstone does have porosity and some permeability even though the value is low. Removing the heavy weathering factor, Kati Beds sandstone around Seri Iskandar area might have the potential to be a good reservoir rock in subsurface. But the depth of the reservoir should be at suitable depth because if it is located too deep in the subsurface, it can also ruin the porosity and the permeability of the rock. Although, the potential is still inconclusive because the extent of the rock in subsurface is unknown due to limited outcrops accessibility.

If the real potential of Kati Beds sandstone in Seri Iskandar area is identified, it will help to prove the presence of a Palaeozoic hydrocarbon system because until now its presence is still speculative, but the possibility cannot be ruled out (Tjia, 1999).

5.2 Limitation and Recommendation

One of the limitation for this project is the limited number of outcrops available to be studied. All of the outcrops location near to each other and make it hard to study the extension of the formation. One recommendation to enhance the product of this project is by shoot a few lines of seismic in the area to identify the extent of the formation in the subsurface.

Another recommendation is if the potential of the reservoir rock in Seri Iskandar area is proven, further study on the source rock that can feed the reservoir can be conducted to include another element of petroleum system in Seri Iskandar area. Hence, if the reservoir is suitably sealed and there is a presence of mature source rock in Seri Iskandar area to produce hydrocarbon, a well can be drill in the area to check the commerciality of the hydrocarbon and can be produced if commercial enough.

CHAPTER 6: REFERENCES

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